Microwave Home Brew

Building a 10GHz Receive Converter

This time in John Cooke GM8OTI's Microwave Home-Brew series he's describing a 10GHz receive converter. John's aiming to get himself – and you – on 10GHz in double-quick time!

My aim with this project is to build a narrow-band system for 10GHz as quickly, and as cheaply, as possible. This will enable me to make contacts using s.s.b. and other narrow-band modes since I don't know anyone locally using the wide band f.m. approach.

Last time I described how I dismantled a satellite TV low noise block (l.n.b.) to provide a signal source at 10GHz. I have used the other board from that l.n.b. to provide the receive side of a transverter for 10GHz.

The board is mounted on an aluminium plate, to replace the base from the l.n.b. which has mouldings like the circular input waveguide on it, and to allow coaxial SMA connectors to be fed through for the input from the antenna and the local oscillator (l.o.). I drilled recesses in the aluminium plate where the board has tracks on the ground plane.

I cut off one of the l.n.b. receive amplifiers with its stripline image filter **(Fig. 1**). The idea was that this would make the transmit amplifier. Some people have reversed an amplifier on a single board by unsoldering and reversing the transistors and their power connections, but this looks difficult. I thought cutting the board up and reversing the amplifier would be easier!

Power for the board (12V) would normally be provided down the coaxial cable feed from the l.n.b. to the TV receiver. I provide the 12V supply directly to the appropriate point on the board which feeds the voltage regulators. The intermediate frequency (i.f.) is taken from the mixer diode, direct to my Yaesu FT-817 transceiver used as the i.f. system.

Another Signal Source

I'm already building a narrow band system for s.s.b. and decided that the Gunn source and dielectric resonator oscillator (d.r.o.) source I had built (*PW* January 2013) were probably not stable enough for tests – and indeed the d.r.o. source can't be tuned far enough to reach the frequencies I want to work at around 10368MHz.

Rather than building another l.o. at a different frequency to test the receiver with the d.r.o. source, it was easier to build a harmonic generator source (**Fig. 2**).

This consists of a block crystal oscillator (36MHz but anything suitable will do) feeding a 74S04 digital buffer (the fastest I could find in the junk box). The fast buffer gives sharp edges to the waveform driving a microwave mixer diode (taken from the board I used for the d.r.o. source) which feeds a wire loop in a short length of waveguide which is the signal output. I hoped that this would give me a detectable harmonic at 10368MHz.

First Tests

To provide an antenna for the receiver, I made a small horn from the base of a biscuit tin (which determined the size of the horn!). I had already found a waveguide to SMA transition at a club junk sale, to connect the horn waveguide to coaxial cable.

I connected up the system and pointed the horn at the harmonic source. Tuning around for the harmonic at 10168MHz, I found a signal near 432MHz (the transverter i.f.) but soon established that this was just the 12th harmonic of the 36MHz source. From its measured frequency (a bit down from 432MHz), I was able to calculate where I should expect to hear the 288th harmonic – 24 times further down in frequency.

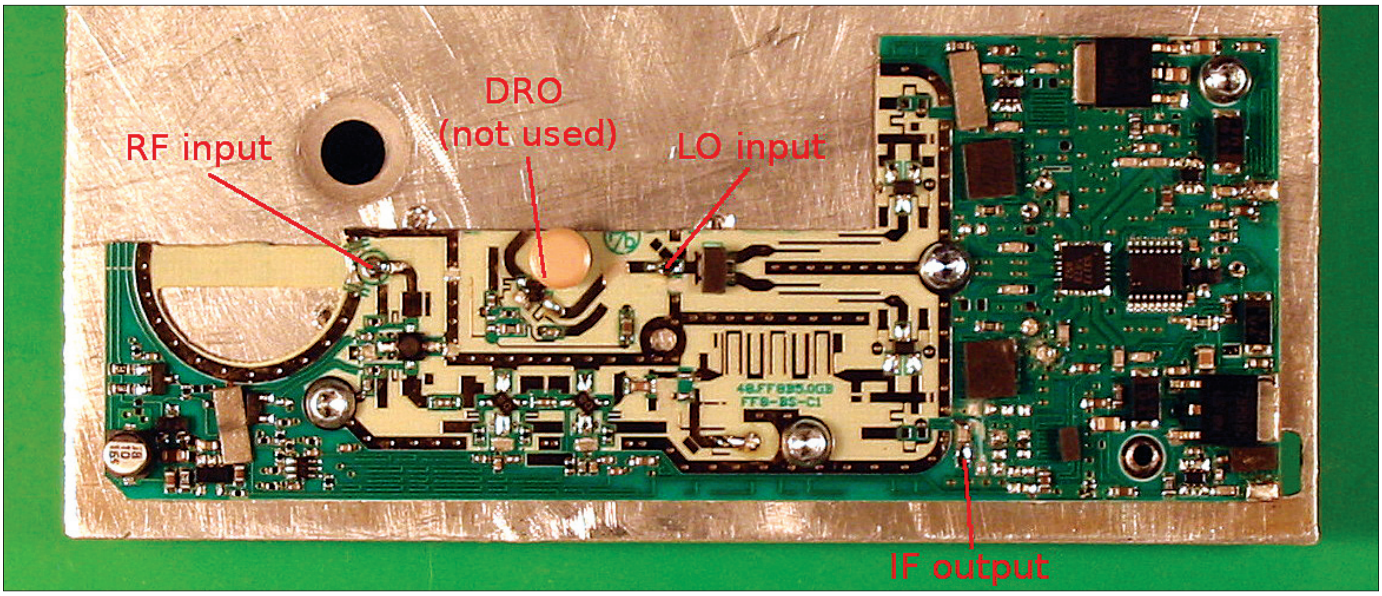


Fig. 1: The receive section on the l.n.b. board. Since this photo John GM8OTI has also removed the spare bit of track next to the l.o. input, since it looked a bit like a quarter wave short at 10GHz!

I detected this 10GHz signal first by taking the screening lid off the l.n.b. board and pointing the open end of the source waveguide just above the mixer diode. I was pleased to hear a clean carrier, and used this to peak up my pipe cap filters in the l.o. multiplier.

Then I put the lid on again and powered up the receiver. I was then able to detect my source from about a metre away, though I could get a good S9 signal on my FT-817 by inserting the source waveguide into the receive horn!

There was soon an opportunity to give the system some better tests. The RSGB May microwave contest was due, and our club (**Lothians Radio Society**) was active on the 10GHz band. The test results were not good – I was able to hear a strong local s.s.b. signal at 10GHz, but it was extremely noisy, so something was not working properly.

Back at home I found out that the local oscillator was not working as expected. The final stage of the multiplier board was oscillating all on its own – it actually produced a signal even with the 1104MHz source disconnected. Tuning up the multiplier had turned it into an oscillator. This was disappointing; I spent some time trying to get rid of the unwanted oscillation, using screening and absorber foam – but with no success at this stage.

Second Multiplier Board

Since the first multiplier didn't seem to work well, I decided to try a different approach. I came across an interesting possibility from **Daniel Uppström SM6VFZ**, who had used ready built amplifiers from a surplus board with NE32584 transistors on it – and I had some of these boards. I used a 2.5GHz voltage controlled oscillator (v.c.o.) from another surplus board, with the output multiplied by four to give me the 9936MHz l.o. I needed (**Fig. 3**).

The multiplier uses a modified amplifier and a 9936MHz filter to select the correct harmonic; I made one like that from Daniel SM6VFZ, out of a strip of transmission line from one of the NE32584 boards. This was fiddly work with a sharp knife! The filter is followed by another NE32584 as an amplifier.

Initial measurements of the output using a borrowed microwave detector diode from **Jon Joyce GM4JTJ** suggested that I would need more drive for the mixer, so I cut out another NE32584 amplifier and built it up on a separate board. A further amplifier from another surplus board was needed to provide enough drive to the multiplier. I also used my wavemeter as a detector, and observed a signal peak at the right wavelength – finally it seemed I had enough signal to drive the mixer.

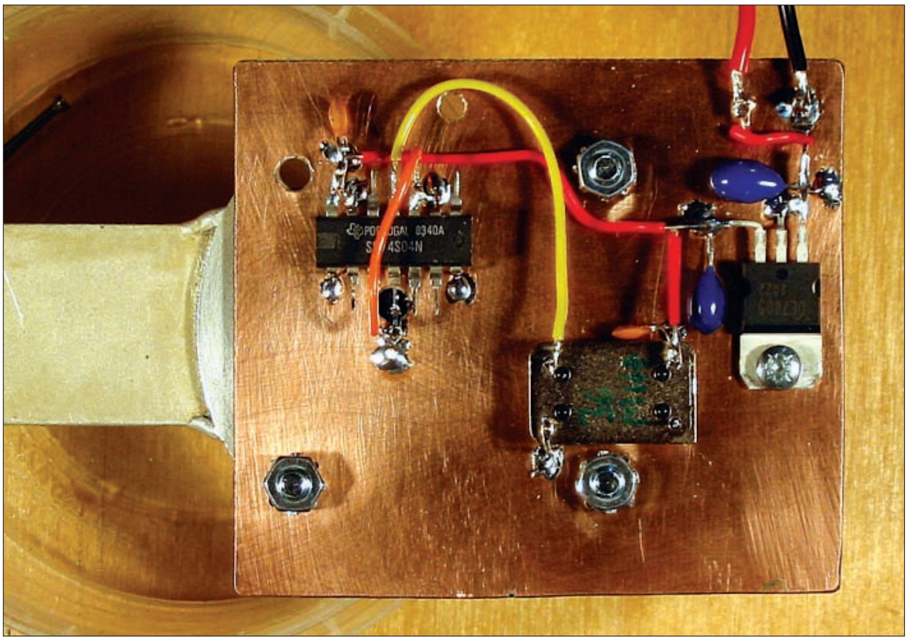


Fig. 2: The block crystal oscillator harmonic source.

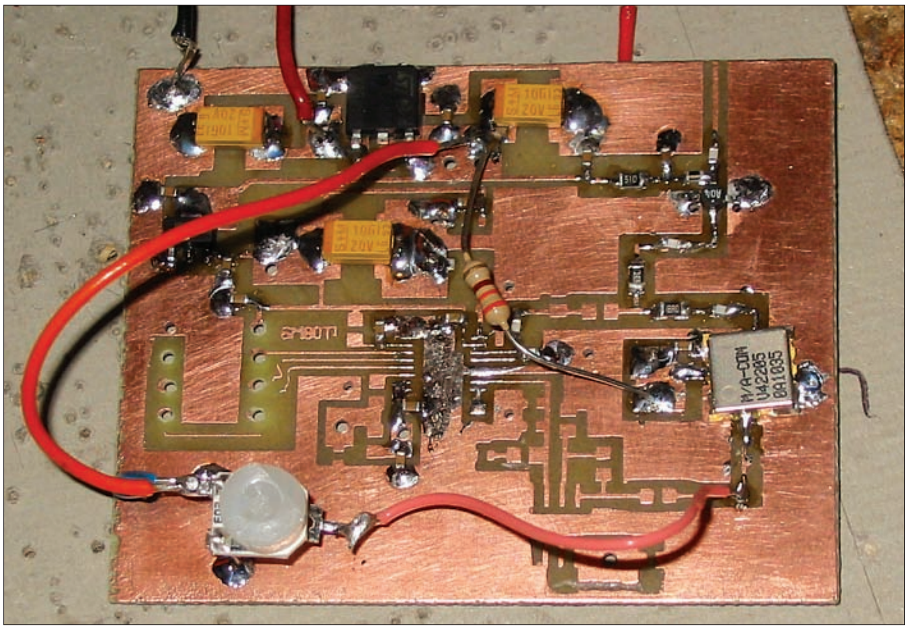
Unfortunately, I still wasn't able to detect a signal from my harmonic generator with the receiver. I built another pipe cap filter, and replaced the stripline filter with it (**Fig. 4**), to see if this improved things. The filter tuned up at the right position for 9936MHz, but I still couldn't detect the expected harmonic.

I realised I had a spare microwave source – the 1104MHz board from the first local oscillator. I re-programmed this to produce 1152MHz, and fed the output into a BAT85 Schottky diode mounted with bias resistors on an SMA socket. This would give a stronger 10368MHz harmonic than the 36MHz block oscillator harmonic generator.

Noisy Indeed

Finally, I was able to detect something with the receiver! Unfortunately, what I detected was very noisy indeed – I

Fig. 3: The 2.5GHz source board during construction, with the v.c.o. under test. I made the traces from the PIC to the PLL chip a bit thin – they were repaired with wire!



measured a broad peak of noise around 200kHz wide, by tuning around on the FT-817. Something was very noisy, either in the l.o. and multiplier chain, or the 1152MHz test source. But what and where was it?

I decided it was time to seek help. I knew that **Brian Flynn GM8BJF** (one of our club members) has a spectrum analyser, so asked if we could have a look at the output from my local oscillator. This confirmed my diagnosis of a broad, noisy source, and located the problem in the l.o. system rather than in the harmonic source.

Additionally, the peak on the analyser looked like an f.m. spectrum, suggesting that the problem lay with the v.c.o. control loop. By disconnecting the v.c.o. control voltage we established that the v.c.o. output is very clean, so the problem had to be somewhere in the voltage control loop on the l.o. source board. Armed with that information, I headed back home!

In retrospect, I realise that it would have been possible to manage without a spectrum analyser; my diagnosis was basically correct, and examining the v.c.o. control voltage in more detail would have revealed the source of the problem.

When I got the receiver home I examined the v.c.o. control voltage. It appeared to be steady, but with a magnified trace on my oscilloscope I could see a small oscillation of about 5mV. By adjusting the control loop filter components I was able to reduce this, but one or two millivolts of noise remained.

To reduce the noise I tried a low noise operational amplifier in the v.c.o. control loop. This produced less noise, but revealed that the oscillation was still there at about the one millivolt level.

The oscillation frequency was 20kHz, which I eventually recalled was the channel separation I'd chosen (more or less at random) when programming the ADF4118. I re-programmed the ADF4118 to use a channel separation of 1MHz, also changing the values for the loop filter components for this frequency. That solved the problem – the oscillation had gone away!

I re-assembled the receiver and was now able to pick up the 10368MHz harmonic of my 36MHz block oscillator source, not strong but definitely present. With the 1152MHz and diode multiplier source, I heard a huge signal that showed Doppler frequency shifts due to my moving about, even in a nearby room!

I was jumping around with excitement that I finally appeared to have a working receiver! (**Fig. 5**)

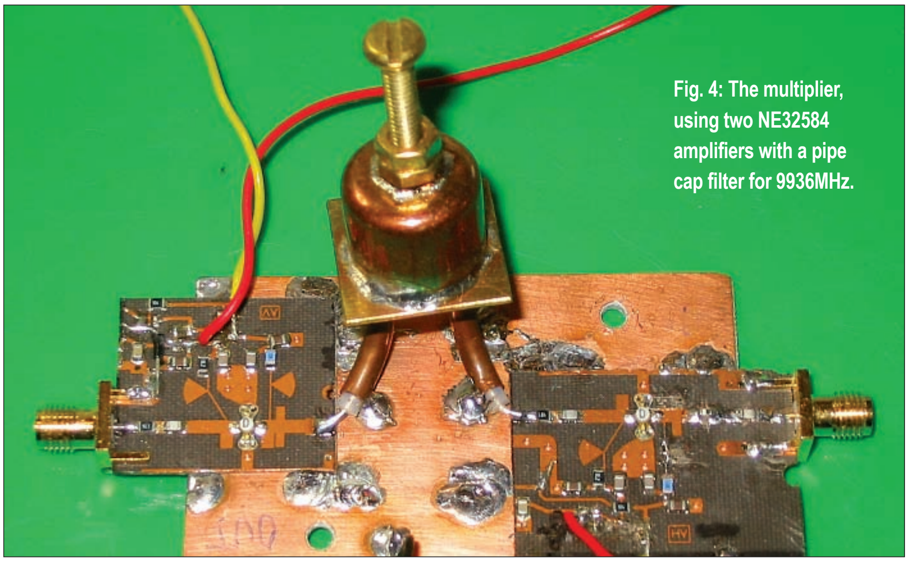


Fig. 4: The multiplier, using two NE32584 amplifiers with a pipe cap filter for 9936MHz.

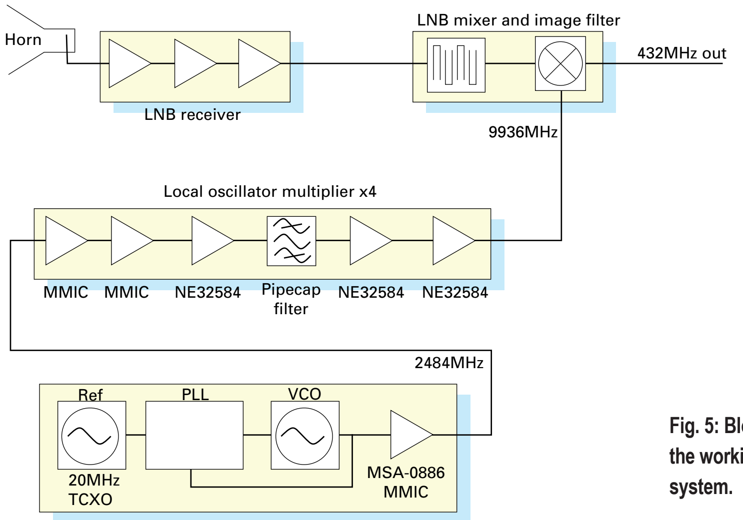


Fig. 5: Block diagram of the working 10GHz receive system.

Tests With Real Signals

The next test was to try to receive a signal from someone else. **Brian Flynn GM8BJF** – who lives nearby – has a personal 10GHz beacon which was now audible even without moving the horn which was pointing inside the room! Once I moved the horn to point through a window at a local hill (where the beacon horn was also pointing), the signal was much stronger.

Some more testing was possible when **Alan Dimmick GM0USI** offered to fit in a test using his 9W p.a.and 1.1m dish set-up for 10GHz. While I was waiting for Alan there was very heavy rain nearby, in which I was able to hear the effects of rainscatter properly for the first time, even on **Brian GM8BJF**'s beacon. The rainscatter also enabled me to hear the personal beacon set up by **Chris Grierson GM4YLN** for the first time.

Chris GM4YLN's beacon is frequency locked using g.p.s. and gave me the offset in frequency of this transverter due to the error in my frequency reference. This means that I need to set the FT-817 5kHz high to be on frequency, which was confirmed when Alan GM0USI, who also has a g.p.s. locked set-up, pointed his dish towards me. I could first hear his c.w. dashes, then very clear s.s.b. at 59+ over a 50km path, which reassured me that my receiver is working well.

In the next article I'll describe what I had to do to get the transmit side of the transverter working, so that I could make that first 10GHz QSO! Cheerio until next time!

Web references

Daniel Uppström SM6VFZ
www.eta.chalmers.se/~upda/quadrupler.html

RF Elettronica (surplus microwave components)
www.rfmicrowave.it/